REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-02-

0136

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
		1 Apr 98 - 1 Sep 01

4. TITLE AND SUBTITLE
(AASERT98) Student Training in Mesopheric, Ionospheric, and Thermospheric Physics

5. FUNDING NUMBERS
F49620-98-1-0359

6. AUTHOR(S)
A. Lyle Broadfoot

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Arizona
Sponsored Projects Services
P.O. Box 3308
Tucson, AZ 85722

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NM
801 N. Randolph Street Room 732
Arlington, VA 22203-1977

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-98-1-0359

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The student training program carried on under this grant was quite successful. Although the support did not go to a single graduate student, many students were encouraged by thier opportunity to be involved in real research projects. This was good experience because we had to go back in the literature more than fifty years to establish a knowledge base.

20020419 171

14. SUBJECT TERMS	15. NUMBER OF PAGES
	4
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

Final Technical Report
(AASERT98)Student Training in Mesospheric, Ionospheric, and Thermospheric Physics

1 April 1998 – 1 September 2001

The student training program carried on under this grant was quite successful. Although the support did not go to a single graduate student, many students were encouraged by their opportunity to be involved in real research projects.

Students Jim Collins and David Sing were involved in support of our shuttle experiments on STS-95, October 1998. The students had a role in planning prior to flight, flight operations, data collections, preparation and analysis. This work finally led to the publication of the paper, *UVSTAR Observations of Adara (ε CMa): 575-1250 Å* by A. Gregorio, R. Stalio, L. Broadfoot, F. Castelli, M. Hack, and J. Holberg, in Astronomy & Astrophysics.

Students Jim Collins and David Sing assisted in preparation of that paper and are continuing their education in astronomy. David Sing was accepted at the University of Arizona Graduate Studies in Astronomy.

In the Airglow and Aeronomy area we were also successful. Students Luke Moore and Mike Hay have both gone to graduate school. Luke Moore will continue in atmospheric studies at Boston University. His participation in the CEDAR conferences were useful in his decision making process. They both became very involved in the GLO data analysis and made major contributions to the recent publication, *Hyperspectral Imaging of the Night Airglow Layer From the Shuttle: A Study of Temporal Variability* by A. Lyle Broadfoot and James A. Gardner published in Journal of Geophysical Research, vol. 106.

This was good experience because we had to go back in the literature more than fifty years to establish a knowledge base. It was important to discover that the theoretical concept could not be validated, and we had to develop new approaches to the data analysis.

Moore and Hay also participated in the literature search leading to the paper, *Remote Sensing From the International Space Station*, by A. Lyle Broadfoot published in Pergamon, vol. 27, nos. 6-7.

Student participation in the Student Satellite Program was valuable experience for these students and is consistent with the objectives of this Student Training Program.

Annual Technical Report #2
(AASERT98)Student Training in Mesospheric, Ionospheric, and Thermospheric Physics

Period: 1 September 1998 – 1 September 1999

The objective of this program is to support a graduate student in a scientific research program. Also to involve students in scientific research that would encourage them to seek higher education in science and engineering. Although we advertised to support graduate students through a three year graduate program in atmospheric physics, very few US students were interested in science. This was common throughout the University.

We were successful in continuing partial support of Jim Collins, a graduate student, in astronomy and astrophysics. He was particularly interested in the astronomical data recorded by the UVSTAR instrument during the STS-95 flight in Nov. 1998. He assisted in the flight activity. He was involved in data organization and analysis. He worked closely with Dr. Jay Holberg of our laboratory and Dr. Roberto Stalio of the University of Trieste.

Another astronomy senior, David Sing, was supported through the school year. He was also an astronomy student and worked closely with Collins supported Holberg and Stalio.

In the airglow and aeronomy area undergraduate students Luke Moore, Peter Jensen, and Michael Hay were employed as in the data analysis laboratory. They became familiar with the Arizona Airglow experiment "GLO" data and data handling procedures. These students were acquired through the University of Arizona Student Satellite Program. They were all involved in the satellite program as volunteers.

Luke Moore continued in the data lab through the summer. He attended the CEDAR meeting in June. He became expert in the handling of GLO data. He appeared to be a candidate for a graduate program.

Annual Technical Report #3
(AASERT98)Student Training in Mesospheric, Ionospheric, and Thermospheric Physics

Period: 1 September 1999 – 1 September 2000

The objective of this program was to involve students in scientific research programs that would encourage them to seek higher education in science and engineering.

Under graduate students, Michael Hay, Luke Moore, and David Sing continued their work in data handling and analysis.

David Sing continued to support Drs. Holberg and Stalio in astronomy and astrophysics. A paper was being prepared on the UVSTAR observations of Adara (ε Cma). Late in the year, Sing graduated with a bachelors degree in astronomy. Within his undergraduate student program he had experiences with shuttle flight and operations in the POCC. He was involved in the observational planning process and subsequent data handling proceeding to scientific analysis.

Michael Hay and Luke Moore continued to assist in the analysis of the GLO data set. The objective was to address hyperspectral imaging of the night airglow. This took a great deal of study since the data set was new and new analysis techniques were required. We found that the accepted theory of the night airglow was incomplete. The theory did not describe the data. Several programs were examined to assist in the analysis. The simple model of Johnston and Broadfoot was used extensively with little success. Finally, we put aside the historical theoretical approach and devised a data presentation that showed the relationship of the primary night glow emissions as hyperspectral images. This was an important step and set the stage for a major paper on hyperspectral imaging of the night airglow.

Both students continued their leadership in the Student Satellite Program. They had become interested in Sprits and were leaders in that science team. There was an attempt to observe sprites from astronomical observatory sites around Tucson. Several attempts were made to capture a sprite image during the thunder storm period. No Sprites were detected but the experience was valuable.

Luke Moore worked in the data lab during the summer. He attended the CEDAR meeting again and prepared a student poster paper on hyperspectral imaging. This had been a rewarding year for the students since we had passed the stage of data handling into the stage of analysis. We dealt with the present status of nightglow physics and the expectations and lack of correlation with the data. Both students became involved in the scientific problem.

Annual Technical Report #4
(AASERT98)Student Training in Mesospheric, Ionospheric, and Thermospheric Physics

1 September 2000 – 1 September 2001

Although the program expired April 1, 2001, a contract extension to 1 September 2001 was granted.

Both Michael Hay and Luke Moore were scheduled to graduate after the first semester of the year.

Michael Hay began a new project, simulating observational geometry for an observer on the International Space Station. A program had been written several years before in a combination of C and Fortran languages. The task was to bring this program up to date and include the real structure of the International Space Station. This involved using an AutoCad drawing of the station and building obscuration masks. This project was completed before the first of the year and is in use by our International Space Station remote sensing planning team.

Michael Hay was accepted as a graduate student at Princeton University. Luke Moore continued to assist in the preparation of the night glow paper on hyperspectral imaging of the night airglow.

Preparation of that paper presented many new concepts that would need to be developed for future analysis. Moore continued after graduation and prepared data for several new approaches suggested by the previous analysis. He attended the CEDAR meeting again. He was accepted as a graduate student at Boston University.

The Student Satellite Program had been taken under the Arizona Space Grant Program as it had expanded its role. The new approach was to build CubeSats. A CubeSat is a small satellite 10cm cubed. This program was endorsed by the National Directors of the Space Grant Program. The idea was that the smaller satellites could be build by the students and flown within their term at the University. Funding had been found for two satellites. The schedule was to prepare the satellites through the school year with a delivery July 30, 2001 and flight in November. This became a very active student program. This program is designed to give students some experience in space engineering and science. Some of the key students preparing the satellites required some support through the summer 2001 period. This student program provided partial support of the following students so that they could continue their work on the CubeSats:

James Cody
Andrew Eatchael
Banessa Gonzalez
David King
David Waboyamor

Launches were planned through Russian rocket opportunities that cost $30-70k per CubeSat. I initiated a plan to have the CubeSats launched from a Shuttle GAS Canister. One of the mechanical engineering students began the design of a GAS Canister Launch Facility. It appears that 40 CubeSats could be launched during one Shuttle flight.